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Supplemental Material

Major Limitations in Using Element Concentrations in Hair as Biomarkers of Exposure to Toxic and Essential Trace Elements in Children

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Table S1. Recommended values for hair reference material NCSZC81002b, obtained values and limits of detection (LOD; μg/kg) for multiple elements in hair.

Element	N	Recommended value (mean ± SD)	Obtained value (mean ± SD)	LOD
Mg (mg/kg)	97	248 ± 14	258 ± 22	0.042
Ca (mg/kg)	97	1537 ± 68	1703 ± 92	0.12
Mn	97	3800 ± 390	3273 ± 308	0.10
Fe (mg/kg)	97	160 ± 16	153 ± 25	0.005
Co	97	150 ± 15	175 ± 69	<0.001
Cu (mg/kg)	97	34 ± 2.3	35 ± 3.0	<0.001
Zn (mg/kg)	97	191 ± 16	194 ± 11	0.009
As	97	200 ± 2.3	196 ± 21	0.014
Se	27	590 ± 40	593 ± 40	0.022
Mo	97	1100 ± 100	1020 ± 121	0.16
Cd	97	72 ± 10	55 ± 6.7	0.008
Pb	97	3830 ± 180	4377 ± 792	0.14

Table S2. Recommended values for reference materials, obtained values and limits of detection (LOD; µg/L) for multiple elements in urine.

		Seronorm ™ Trace Elements Urine; 1011645		Seronorm ™ Trace Elements Urine; 1011644		
Element	N	Recommended value (mean ± SD) / Range[a]	Obtained value (mean ± SD)	Recommended value (mean ± SD) / Range[a]	Obtained value (mean ± SD)	LOD
Mn	15	11 ± 2.2 / 6.5-15.3	10 ± 0.29	0.73 ± 0.15 / 0.44-1.02	0.73 ± 0.050	0.004
Fe	15	14[b]	17 ± 4.7	14[a]	15 ± 2.9	0.27
Co	15	11 ± 2.1 / 6.4-14.8	9.8 ± 0.40	0.72 ± 0.15 / 0.43-1.01	0.67 ± 0.023	0.002
Cu	15	22[b]	20 ± 1.1	31[b]	26 ± 1.2	0.078
Zn	15	1338 ± 269 / 800-1876	1131 ± 63	334 ± 67 / 200-468	295 ± 15	0.25
As	15	184 ± 37 / 110-258	184 ± 4.5	79 ± 16 / 47-111	81 ± 1.5	0.042
Se	15	70 ± 14 / 41.9-98.3	74 ± 4.4	14 ± 2.8 / 8.3-19.5	15 ± 0.46	0.004
Mo	15	38[b]	39 ± 2.2	37[b]	40 ± 1.8	0.034
Cd	15	4.9 ± 0.20 / 4.4-5.4	5.0 ± 0.12	0.20 ± 0.040 / 0.13-0.27	0.15 ± 0.0060	<0.001
Pb	15	91 ± 18 / 54.1-127.3	86 ± 2.8	0.66 ± 0.13 / 0.39-0.93	0.54 ± 0.031	<0.001

[a] Acceptable range (SERO's assessment)
[b] Approximate value

Table S3. Recommended values for two reference materials, obtained values[a] and limits of detection (LOD; µg/L) for multiple elements in erythrocytes.

		Seronorm ™ Trace Elements Whole Blood L-1; LOT 1103128			Seronorm ™ Trace Elements Whole Blood L-2; LOT 1103129		
Element	N	Recommended value (mean ± SD) / Range[b]	Obtained value (mean ± SD)	N	Recommended value (mean ± SD) / Range[b]	Obtained value (mean ± SD)	LOD
Mn	29	21 ± 4.2 / 12.3-29.1	20 ± 0.40	27	30 ± 6.0 / 17.9-41.9	30 ± 0.59	0.012
Fe (mg/kg)	29	331[c]	287 ± 15	27	319[c]	286 ± 15	0.31
Co	29	0.16 ± 0.030 / 0.10-0.22	0.16 ± 0.030	27	5.8 ± 1.2 / 3.5-8.1	5.5 ± 0.15	0.003
Cu	29	680 ± 140 / 410-950	593 ± 19	27	1330 ± 270/ 790-1870	1255 ± 39	0.047
Zn	29	4400 ± 200 /4000-4800	3999 ± 124	27	6500 ± 300/ 5800-7200	6252 ± 180	0.68
As	29	2.4 ± 0.5 / 1.4-3.4	2.3 ± 0.21	27	14 ± 2.9 / 8.5-20.1	15 ± 1.4	0.014
Se	29	59 ± 12 / 35-83	58 ± 1.5	27	112 ± 23 / 66-158	121 ± 2.5	0.006
Mo	29	0.94 ± 0.22 / 0.61-1.27	1.0 ± 0.072	27	6.4 ± 1.3 / 3.84-9.00	6.5 ± 0.29	0.002
Cd	29	0.36 ± 0.020 /0.32-0.40	0.31 ± 0.033	27	5.8 ± 0.20 7 / 5.4-6.2	5.8 ± 0.12	0.003
Pb	29	10 ± 2.1 / 6.0-14.4	10 ± 0.23	27	310 ± 62 / 186-434	316 ± 3.7	0.009

[a] Obtained values (originally µg/kg) recalculated to µg/L assuming a blood density of 1.060 g/ml
[b] Acceptable range (SERO's assessment)
[c] Additional value

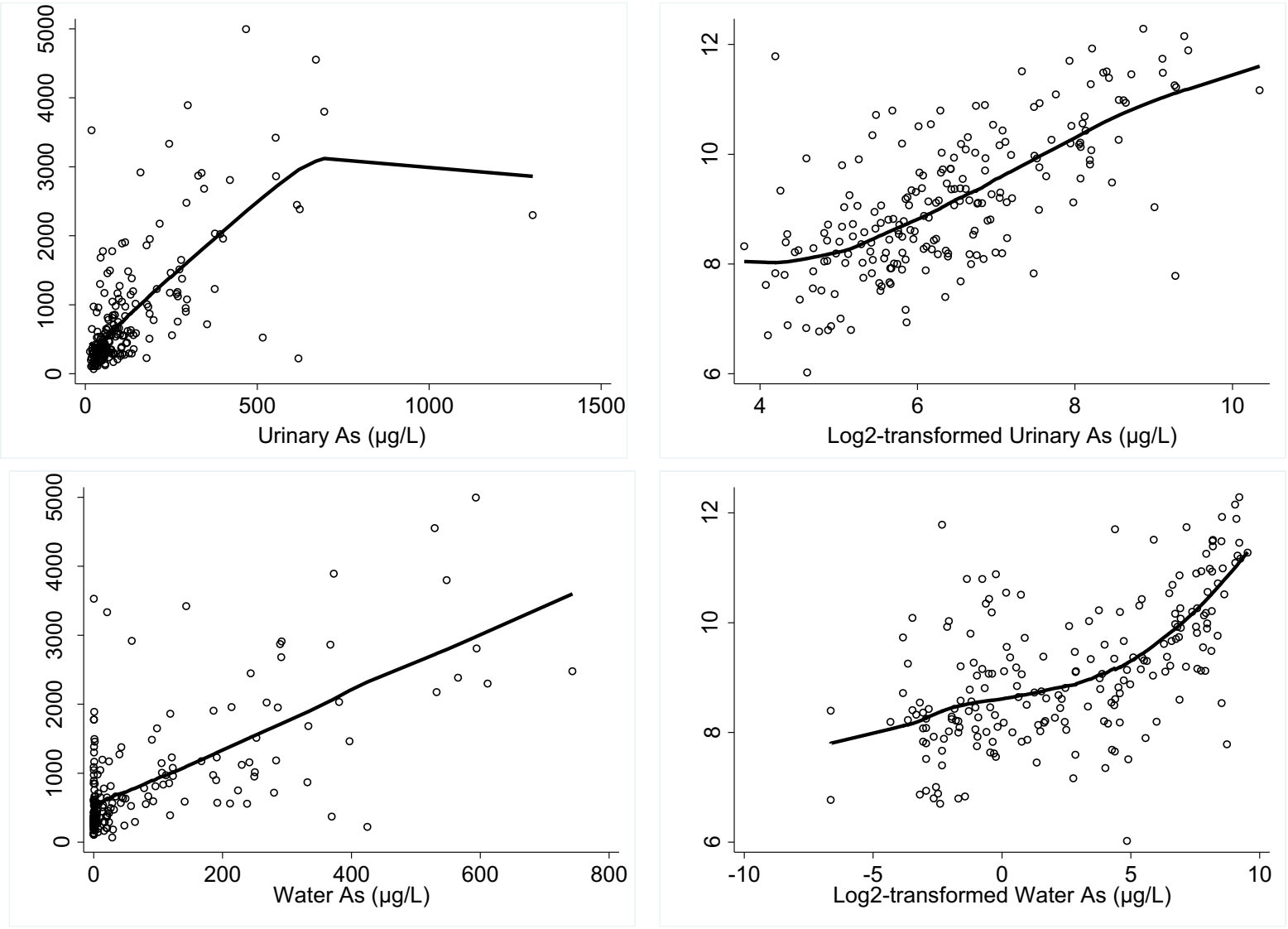
Table S4. Spearman correlations (p-value) between all analyzed elements in hair at 10 years of age (n=207).

	Ca	Mg	Fe	Co	Cu	Zn	As	Se	Mo	Cd	Pb
Mg	0.76 (<0.001)	0.43 (<0.001)	0.46 (<0.001)	0.62 (<0.001)	0.098 (0.16)	0.28 (<0.001)	0.073 (0.30)	0.069 (0.32)	0.083 (0.24)	0.066 (0.34)	-0.049 (0.48)
Ca		0.55 (<0.001)	0.31 (<0.001)	0.56 (<0.001)	0.062 (0.37)	0.27 (<0.001)	0.0015 (0.98)	0.062 (0.37)	0.12 (0.081)	0.066 (0.35)	-0.099 (0.16)
Mn			0.23 (0.0011)	0.54 (<0.001)	0.15 (0.030)	-0.062 (0.37)	0.056 (0.42)	-0.12 (0.092)	0.23 (0.0010)	0.39 (<0.001)	0.40 (<0.001)
Fe				0.80 (<0.001)	-0.034 (0.62)	0.0020 (0.98)	0.13 (0.053)	0.18 (0.0085)	0.20 (0.0038)	0.029 (0.68)	0.053 (0.45)
Co					0.080 (0.25)	0.079 (0.26)	0.027 (0.70)	0.18 (0.0093)	0.24 (<0.001)	0.16 (0.020)	0.15 (0.035)
Cu						0.12 (0.096)	-0.028 (0.69)	0.040 (0.57)	0.13 (0.057)	0.21 (0.0027)	0.25 (<0.001)
Zn							-0.064 (0.36)	0.23 (<0.001)	-0.065 (0.35)	-0.22 (0.0015)	-0.48 (<0.001)
As								-0.011 (0.88)	0.24 (<0.001)	0.072 (0.30)	0.082 (0.24)
Se									0.25 (<0.001)	0.029 (0.67)	-0.098 (0.16)
Mo										0.17 (0.014)	0.19 (0.0071)
Cd											0.58 (<0.001)

	Hair segments from scalp outwards			
Element	1st-2nd cm	3rd-4th cm	5th-6th cm	7th-8th cm
Magnesium				
Calcium				
Manganese				
Iron				
Cobalt				
Copper				
Zinc				
Arsenic				
Selenium				
Molybdenum				
Cadmium				
Lead				

0.5-0.99	
1.0 (reference)	
1.01-1.5	
1.51-2.0	
2.0-2.5	
2.51-3.0	
3.01-3.5	
3.51-4.0	
4.01-4.5	
4.51-5.0	

Figure S1. Increase in trace element concentrations along the hair (from scalp outwards) in 19 girls. The colors represent times increase relative to the first two cm. Only arsenic and selenium decreased slightly. The 1st-2nd cm represent recent exposure, and the 7th-8th cm exposure 8-10 months previously.



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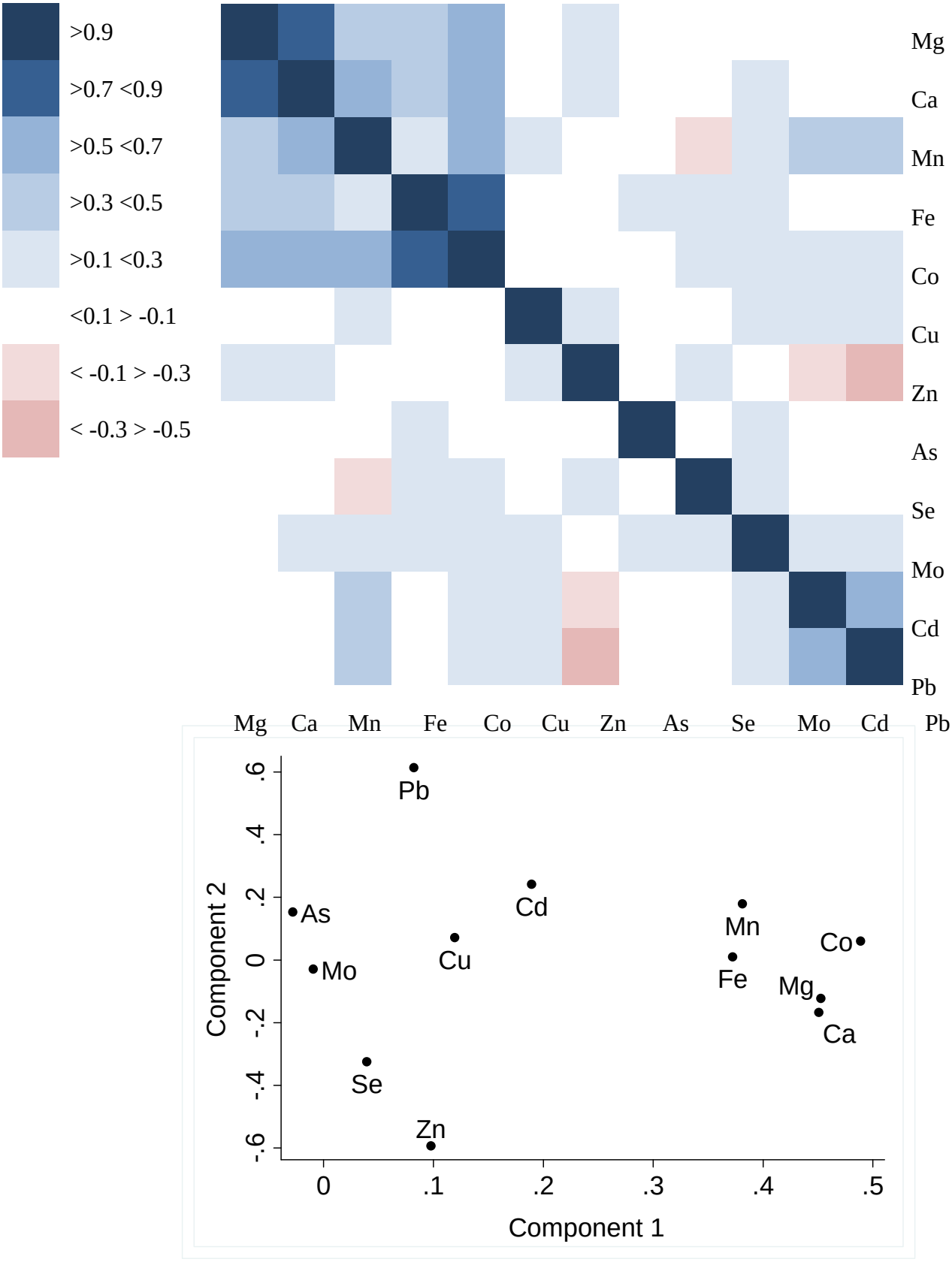

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